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## Editorial

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Several recent collapses of decks and balconies have illustrated the need for improved design and construction practices. Concerns over improper construction details which can create moisture-trapping joints has been raised as one of the factors in the collapse of several decks last summer in Berkeley, California.

The Wood Design Focus editorial board believes that the issues of deck safety and deck construction are essential for protecting the safety of homeowners. This is the first of two issues devoted to the topic of deck construction.

In this issue, we feature two articles focused on inspection of decks and detailing the proper connections and joints. The first article is written by Glenn Mathewson, and represents a building code official perspective on decks. The second article is written by John Bouldin and Bruce Barker and presents a home inspector perspective on deck construction.

Many of the illustrations demonstrate improper details or non-compliant practices. These pictures are offered to help edify the community on these particular practices.

We hope you find this issue helpful in improving deck construction.

Daniel Hindman, PE

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## WOOD DESIGN FOCUS

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# Inspection of Rehabilitated Decks

*Glenn Mathewson*

## **Introduction**

The job of inspecting new decks has evolved since the publishing of the 2009 International Residential Code (IRC), where specific deck ledger connections were first mentioned. The 2015 edition of the IRC saw a major push toward comprehensive deck code provisions, but there are still many structural conditions it does not address. This leaves the majority of the barbecues in this country held on decks built prior to any national standard. There are also architectural details outside of the code that are necessary for a minimum-standard performing structure. Flashing at a ledger, for example, is merely required by the code, but not detailed for installation. Quite frankly, and not just speaking of engineering, the building science of decks is not really understood. Decks are an animal on to their own; not a typical floor, but not exactly a roof. Decks are not protected by a water resistive membrane or cladding, and do not have a clear drainage plane. The geometry is like no other outdoor structural feature, and the variety of design, products, and environment makes what is right in one place for one deck is not correct for a different deck elsewhere. There is much still for mankind to learn about decks.

As a governmental building inspector, I only see new decks, based on today's standards. However, I also see many seemingly innocent deck expansions, remodeling or refacing (new decking and guards) that reveal the skeletons in the closet of the original deck. These situations are always tricky, and balancing owner rights, building safety, and minimum standards often conjures the notorious phrase of "grandfathered in". As a professional charged with building safety, there is an ethical difficulty in leaning on that phrase. The code is

*Keywords: Deck building codes, deck rehabilitation, deck rehabbing, deck expansion, deck inspection, 2015 IRC*

modified every three years, so it generally doesn't take long before every structure is no longer "up to code", but this doesn't necessarily mean it's not "safe". True, society's accepted definition of "safe" is reflected in each new code, but it's a reflection more of society's expectation than of the structure's actual hazard. For decks, however, this philosophy falls apart. The decks of the past were not safe, are not safe, and they never represented society's official definition of safe. There were no standards of safety at the time many were built. Dare I say as society...we winged it. Time has shown that the wings have fallen off, and so are many decks.

## **Ledger Connections**

Ledgers are a primary target for rehab when any deck is remodeled or extended. There is no redundancy to this connection, so a failure can only be catastrophic. This is also a connection that has evolved over the decades from simple nails and ledger strips, to overly detailed bolting and often excessive lateral anchorage. However, ledger design is not just a connection concern. Poor or overlooked flashing above the ledger allows for decay to occur out of sight from casual visual inspections. A deck is going to get wet, that's natural, but it needs to be able to dry. Moisture trapped behind the ledger and against the band joist is a recipe for decay. While ledgers are now required to be decay resistance, previous versions of the IRC did not require this, nor for a typical band joist either. While water-resistive barriers are required today, there was a period in the past where over OSB, they weren't required.

No matter how many lag screw heads can be seen on the face of the ledger or installed, these fasteners have little function if connected to a rotten band joist. If ledger decay is so severe that it is visible on the exposed face, then there is no repair or rehab to be done, a complete replacement may be necessary.



**Figure 1. Ledger Plate Showing Water Staining**

Often revealing rehab required to the structure the deck was attached to as well. However, if it's not, there is more investigation necessary before hanging new joists or resurfacing them. Remove the deck boards from above the ledger, and take a good, close look at the flashing and ledger condition.

- Are there signs of decay or corrosion?
- Is the inside of the band joist visible, such as in a crawl space or an unfinished basement? Have a look. Similar to the ledger, you will only see the exposed face and not the one where moisture can be trapped.
- Look closely at the area around the lag screw, as this is where decay will first migrate through.

This is not an easy inspection, so be conservative when deciding the ledger, band joist, and flashing is acceptable for another generation of refaced life. If the deck was built more than 10 years ago, I would certainly error any uncertainty to complete replacement. Other clues to look for that would suggest ledger replacement are if it is attached directly over stucco, siding, or brick veneer. The ledger should not have any exterior cladding or veneer inside the connection to the band joist. Like the shirt on your back, exterior cladding and veneers are not structural components. They are shells. You wouldn't stitch your shirt into your chest after open heart surgery would you? Same for the ledger.

### **Post to Beam Connection**

Post to beam connections are another outlaw from the Wild West of deck building that we have only recently reigned in. Countless posts are attached to beams with merely a few toenails. However, like any wood to wood connection on decks exposed to weather, drying potential is significantly reduced in the small spaces between the members, between the post and beam. This is also a point where all the loads from the deck are transmitted to the post through a relatively small bearing area on the bottom of the beam. As decays begins to occur on the beam, failure may be more rapid due to imposed concentrated loads. Time has revealed that this connection will slip as the wood decays from the perpendicular to grain loading and stability is lost. In many cases, if decays has not yet begun, this can be corrected with a various assortment of tested post cap products available on the market. Many of which can be installed without having to take the connection apart.

Another bad habit of our past, one that is still mistakenly employed by many today, is attaching beam plies to the side of a post with bolts. This connection does not provide any direct bearing of the beam plies, as required by the IRC. While this connection could be designed by an engineer, it's not typical for that level of attention to be provided in the design of most decks built in the country, both past and present. Many mistakenly quote the strength of a 1/2" through bolt and dismiss the notion that the connection is unacceptable, but they are



**Figure 2. Intersection of Deck Framing With Wrapped Column. Proper Detailing of Moisture Removal Is Needed To Prevent Moisture Accumulation Within Framing**

forgetting about one of Newton's Laws of Physics. For every action there is an equal and opposite reaction. This means that whatever force the bolt experiences in a wood to wood connection, the wood is experiencing the same force. The question is not the shear strength of the bolt, likely sufficient for most deck loads, but the strength of the wood the bolt is pressing against. In a side-saddled beam to post connection, the force on the beam is perpendicular to grain and placed over an area only 1/2" wide (the diameter of the bolt). Pre-engineered metal hardware can be used to retrofit connections. This is helpful both for new decks built with a side mounted beam and for older decks.

However, some post-to-beam connections can't be inspected, because of exterior coatings such as brick, stone, or stucco column. Decay in these members can be especially hard to locate. There is no drying potential, and often very poor execution in the interface of the framing, column cladding, and decking. Rarely do I see these built to last, and always the signs of failure will be hidden. Evaluating these locations for reuse in a deck rehab relies greatly on indirect signs outside of the actual connection.

- Is the beam a decay-resistant material?
- Is the cladding well installed and directing bulk water down the face, or is the decking penetrating the

cladding and allowing a path for moisture into the column.

- Is the column well flashed if it terminates at the deck level or what is the condition of the cap if it extends to guard rail height?

These clues can never completely reveal the condition of the post-to-beam connection, but they can provide fair reason for an inspector to require destructive evaluation inside the column. These are difficult calls when it comes to balancing the power of government regulation with the limit of financial investment from the owner.

Multi-ply beams are another victim of an inability to dry and resulting decay. The small spaces between the plies of built-up beams allow for easy entrance of moisture, yet reduced capacity for drying. Today, many deck are required by code to be built with decay-resistant materials, such as pressure-preservative-treated lumber, but that's the extent the "minimum standard" has over reducing decay. Various "good practice" methods are used amongst professional builders and marketed by product manufacturers that reveal a greater need to address these areas. Many builders opt for larger, solid-sawn lumber that can make the span as a single members, such as 4x and 6x heavy timber, or glued-laminated beams and other engineered lumber, like treated parallel strand lumber (PSL). There are many

flashing options for the top of beams, such as rigid plastic caps or strips of self-adhering modified bitumen. While these methods are employed by many builders of new decks today, they are still the minority, and definitely not something seen in many decks built in the past being rehabbed today. Capping or protecting the top of an old multi-ply beam in a rehab might eliminate future decay, but will not address any decay and deterioration that has already occurred. Like all the locations discussed thus far, where decay is most prevalent is also where inspection is least possible.

## **Conclusion**

The decking industry is in midst of a coming of age that it has never before experienced. The societal demands for “outdoor living” has been provided for by architectural design and product creativity for over a decade, but the standards of construction that provide a long, safe and consistent life for these designs and products is only now starting to catch up. Still far behind the lead of the society, standards will continue to require the professional contributions of the licensed engineering and architecture community to fill in the blanks for individual projects and for standard development. There is still much for mankind to learn in deck construction, and it will take the experience of many to put the puzzle together.

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# Common Deck Construction Issues From an Inspector's Point of View

*John C. Bouldin, PhD, Bruce Barker*

## **Abstract**

In comparison to some elements of residential construction, decks appear to be rather simple structures. Code provisions for decks have been updated regularly in recent years as knowledge of deck safety and construction methods has improved through research and experience. Yet observations from the field suggest that significant problems are still present in deck construction. The purpose of this paper is to present a brief overview of construction standards for residential wooden decks and to highlight some of the most serious defects that occur in residential decks based on the observations of experienced home inspectors. These observations are based on deck conditions found during thousands of home inspections done by multiple inspectors performed over a period of more than twenty years, and in several different states. The primary areas of deck defects that will be addressed include galvanic corrosion, the ledger-to-band joist connection, flashing, the guard post-to-deck connection, stairways, and connector hardware. Results of this work suggest that by having a knowledge of what actually goes wrong in deck construction, improvements in code language, design specifications (where applicable), and inspection procedures may help to detect or prevent these issues.

## **Introduction**

In comparison to some elements of residential construction, decks appear to be rather simple structures. Code provisions for decks have been updated regularly in recent years as knowledge of deck safety and construction methods has improved through research and experience. Yet observations from the field suggest that significant problems are still present in deck construction. The purpose of this paper is to present a brief overview of construction standards for residential wooden decks, and to highlight some of the most serious defects that occur in

residential decks based on the observations of experienced home inspectors. These observations are based on deck conditions found during thousands of home inspections done by multiple inspectors performed over a period of more than twenty years, and in several different states. The primary areas of deck defects that will be addressed include galvanic corrosion, the ledger-to-band joist connection, flashing, the guard post-to-deck connection, stairways, and connectors. Although not a construction defect per se, older decks can present more problems than newer ones due to aging and functional obsolescence. The service life of a deck depends on many factors, but is generally considered to be in the 20 year old range (NAHB 2007). Many existing decks are at or near the end of their expected service life.

## **Codes and Standards**

In jurisdictions subject to code requirements, new decks are inspected by the building code official, who can enforce compliance upon the builders of decks for any deficiencies. The applicable codes are those approved by the state and/or local municipalities. In addition to these codes, installation instructions for manufactured products such as connector hardware are incorporated by reference into many codes. Although specific installation requirements for these products cannot be found directly in the building code, they are also enforceable. As a result, even qualified contractors may find it difficult to adhere to the entire suite of applicable codes, even with the best of intentions. For non-professional deck builders the task may be overwhelming. For existing decks, there is no requirement for inspections after the fact to ensure the continued safe function of the deck.

Building codes and construction standards are constantly changing in response to new developments in research and in recognition that previously accepted construction methods may no longer be adequate. In short, these

standards are a moving target.

This moving target presents a challenge when inspecting existing decks that may have complied with standards when built, but may not comply with current standards. Existing decks are not subject to the requirements of current standards, however, inspectors need to have some standard for evaluation. Under these circumstances, home inspectors often use current building code and/or best practice guidelines as a basis for evaluation. This paper will rely on two such sources: the 2015 edition of the *International Residential Code* (IRC) (ICC 2014a) as the primary model code for deck construction, and *Design for Code Acceptance 6 Prescriptive Residential Wood Deck Construction Guide* (DCA 6) (AWC 2015). The intent of the IRC is found in Section R101.3 “The purpose of this code is to establish minimum requirements to safeguard the public safety, health, and general welfare...” (ICC 2014a). DCA 6 (AWC 2015), on the other hand, is considered by many to present best practices rather than minimum standards in deck construction.

Developments in deck research have provided a better understanding of the loads and necessary support conditions that proper deck design and construction should include. Research conducted by Parsons et al. (2013a, 2013b) Carradine et al. (2006), Loferski et al. (2006), Loferski and Woeste (2005,2010), and Woeste and Loferski (2005) has resulted in changes to the building code to address construction problems that previously were not adequately addressed. This body of work has given rise to changes in the building code that include enhancements to connections involving deck ledgers, guard posts, and lateral load connectors among other things.

### ***Development and Use of Code Language in the IRC***

The IRC is a prescriptive code, meaning that persons who are not architects or engineers can design and build residential structures by looking up prescribed methods of construction that are deemed to comply with the performance standards found in the *International Building Code* (ICC 2014b). One potential source of deck construction defects may be due to a lack of clarity and consistency in how code specifications are presented, which can result in builders not being able to understand the actual meaning of the code. The attachment of bearing ledgers is one example of this confusion. The first mention of decks in the IRC was in the 2000 edition (ICC 2000). This was a subsection of floor framing that required deck ledgers attached to the house to “be

positively anchored to the primary structure and designed for both vertical and lateral loads as applicable” (IRC section R502.2.1) (ICC 2000). Evidence from the field suggests that this language, especially the lateral load support requirement, has been difficult to interpret and apply for many IRC users. This may be due to the lack of prescriptive guidance about how to install deck ledgers to comply with the intent of the stated requirements for *both* vertical and lateral load connectors or to provide a designed engineering solution to comply with the requirement.

The language found in the 2000 IRC (ICC 2000) continued effectively unchanged until the 2009 version of the IRC (ICC 2009) when prescriptive guidance was added about attachment of deck ledgers to the house. This guidance was clear about methods to attach a deck ledger to the house band joist/rim board to support vertical loads. However, potential confusion remained regarding construction methods to support lateral loads.

This lack of clarity is found in the wording of section R502.2.2.3: Deck lateral load connection: “The lateral load connection required by Section R502.2.2 shall be permitted (emphasis added by the authors) to be in accordance with Figure R502.2.2.3” (ICC 2009). The remaining language of this subsection and the figure showed installation of lateral load connectors, but there was no text specifically requiring use of the lateral load connectors. The potential problem comes from the fact that the “shall be permitted” language implies that this is an optional or alternate method to comply, though it appears to be a requirement based on Figure R502.2.2.3. Evidence from the field suggests that many interpret this subsection as optional. The authors of this article rarely seen these connectors in the field, and have asked hundreds of home inspectors across the country if they have seen lateral load connectors. The overwhelming answer is very rarely.

In the 2012 IRC (ICC 2011), deck construction was given a separate section, R507. Additional prescriptive guidance was added to help clarify how to build a deck in both the 2012 IRC (ICC 2012), and the 2015 IRC (ICC 2014a). However, it should be noted that R507 is not a stand-alone reference for all elements of deck construction. For example, flashing requirements are in Section R703.8.

DCA 6 (AWC 2015) can be very useful in circumstances where code language may be less than clear. DCA 6 has been adopted in whole or in part in many jurisdictions, but not all. It provides detailed



**Figure 1. Corrosion of Metal Deck Fastener**

specifications for most elements of proper deck construction, some of which exceed code requirements in many jurisdictions.

**Code Language Changes in the 2015 IRC**

A significant lack of prescriptive guidance remains in the 2015 IRC (ICC 2014). Although the IRC is a prescriptive code, it specifies a performance standard for guard post connections (ability to support an allowable load of 200 lbs per Table R301.5 (ICC 2014a)), rather than a prescriptive standard on how to construct them.



**Figure 2. Corrosion of Hold-Down And Fastener. Improper Fastener Use**

One upcoming change in IRC specifications could give rise to a nearly undetectable code violation. The 2015 IRC (ICC 2014a) specifies the requirement for the type of pressure preservative treated (PPT) lumber used in most deck components based on the American Wood Protection Association’s (AWPA) *Use Category System U1* (AWPA 2015). U1 is the standard that determines what type of preservative treatment system and what retention level should be used. For example, UC2 treated wood may be used as interior sill plates while UC5C should be used when exposed to salt water in coastal areas and similar environments.

The current standard, U1-15, allows U3B (above ground exposed) treated wood to be used for components such as the deck ledger and joists. The new standard (U1-16) that is scheduled to become effective in June 2016 requires that most deck lumber be U4A (ground contact general use) or better. Exceptions include guards and handrails that are not in contact with the ground. Deck floor boards that are six inches or more above the ground may be required to be U4A depending on conditions of use.

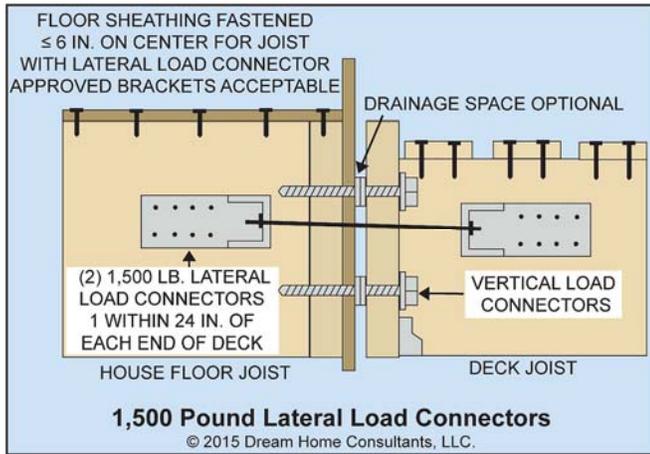
The challenge from an inspection perspective is that there is no means to visually determine lumber preservative treatment category once the manufacturer’s tag is removed. In the absence of identification tags, one piece of preservative treated lumber looks similar to another piece and a lack of ground-contact treatment levels may be nearly impossible to determine.

**Observed Common Problem Areas**

The problem areas addressed in this section mostly come from observations of existing decks. An understanding of these issues and their persistence over time might be instructive for the continued development and application of proper prescriptive construction methods.

**Galvanic Corrosion and Dissimilar Metals in Pressure Treated Lumber**

The chemical composition of most PPT lumber for residential use changed significantly beginning January 1, 2004. The chemical compound that was used prior to this date was Chromated Copper Arsenate (CCA), which provided excellent results but was voluntarily withdrawn from the residential marketplace due to toxicity fears related to the chromium and arsenate components in the formulation. Existing inventories of CCA were allowed to be sold beyond this date but no new CCA PPT was allowed to be sold for residential use thereafter.

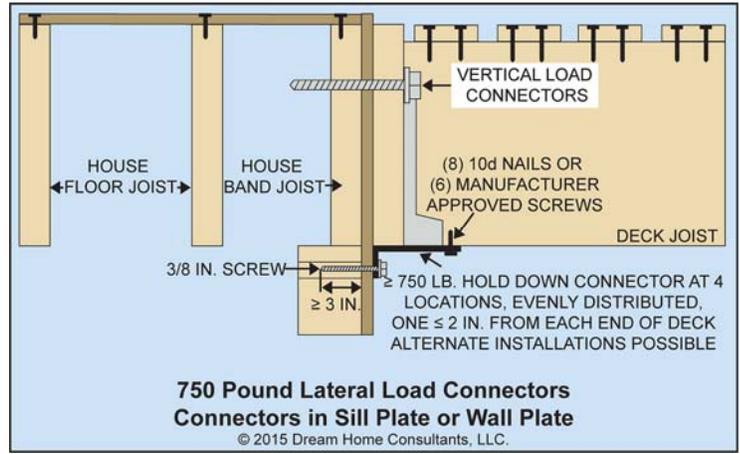


**Figure 3. Deck Ledger Connection with Floor Joists Parallel to Deck Joists Using Threaded Rod**

The two most common replacement chemical treatments, Alkaline Copper Quaternary (ACQ) and Copper Azole (CA), rely on a higher copper content to suppress wood damage from decay fungi and wood destroying insects. Due to the potential for galvanic corrosion, this resulted in an incompatibility with the electro-galvanized fasteners, connection hardware, and with the aluminum flashing then in use. Instead, hot-dipped galvanized or stainless steel fasteners, and alternative flashing materials should be used with ACQ and CA in order to prevent corrosion.

According to the Stainless Steel Information Center (SSINA 2016), when in direct contact with each other in the presence of an electrolyte such as water, dissimilar metals that tend toward opposite ends of the anode-cathode spectrum will produce galvanic corrosion in the more active metal. The more noble (less active) copper in the PPT wood acts as the cathode, which, in the presence of moisture, can cause under-protected steel fasteners or aluminum flashing (both more active) to act as a sacrificial anode. This results in corrosion of the anodic metals.

The authors' experience suggests that proper fasteners, connectors, and flashing on decks built with ACQ and CA decks were not used on a consistent basis for at least a one- to two-year period after January 1, 2004. Therefore, a number of decks built between 2004 and 2006 (approximately) may be at an increased risk of connection failure due to galvanic corrosion. Figure 1 is a photograph of a rusting fastener taken a few months after installation and after the changeover in chemical formulation, suggesting that electro-galvanized, rather than hot-dipped galvanized fasteners were used. Figure 2 is a photograph of corrosion on a hold-down fasteners used on an exterior walkway deck structure that was



**Figure 4. Deck Ledger Connection with Floor Joists Perpendicular to Deck Joists**

installed much later.

### **Deck Ledger Attachment – Vertical and Lateral Loads**

Detachment of the deck ledger from the house is a common failure mode in many catastrophic deck collapses. Because of this, the IRC and DCA 6 contain good prescriptive guidance about how to attach the deck ledger to the band joist/rim board to resist *vertical* loads. These specifications assume: (1) a nominal two inch thick dimension lumber band joist or a one inch or thicker engineered rim board that is approved by the manufacturer for deck ledger connection, (2) the floor joists are perpendicular to the band joist/rim board, (3) the ledger is not attached through wall covering, especially brick veneer, (4) there is not more than one inch between the band joist/rim board and the deck ledger.

As previously mentioned, lateral load specifications are less clear. Lateral connectors which appear to have been required for the past several code iterations are rarely installed. These threaded rod-type connectors are difficult to install even under ideal conditions. Figure 3 shows a typical detail. Note the requirement for extra fasteners in the floor sheathing. Installing threaded rod-type lateral load connectors under less than ideal conditions, especially in retrofit situations, has the potential to be very difficult and expensive. The 2015 IRC (ICC 2014a) provides a prescriptive solution to the lateral load connector issue. Instead of a difficult to install threaded rod-type connector, a connector that screws into a wall plate can be used, such as a Simpson StrongTie DTT1 (Figure 4). Alternatively, the deck can be built as a free-standing structure.

### **Deck Ledger Attachment to House Cantilevers**

Although ledger attachments to house cantilevers are



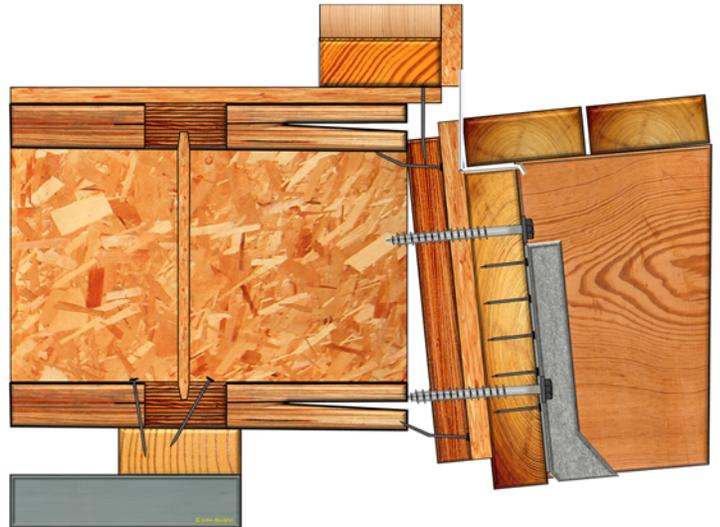
**Figure 5. Example of Deck Ledger Attachment to House Cantilever**



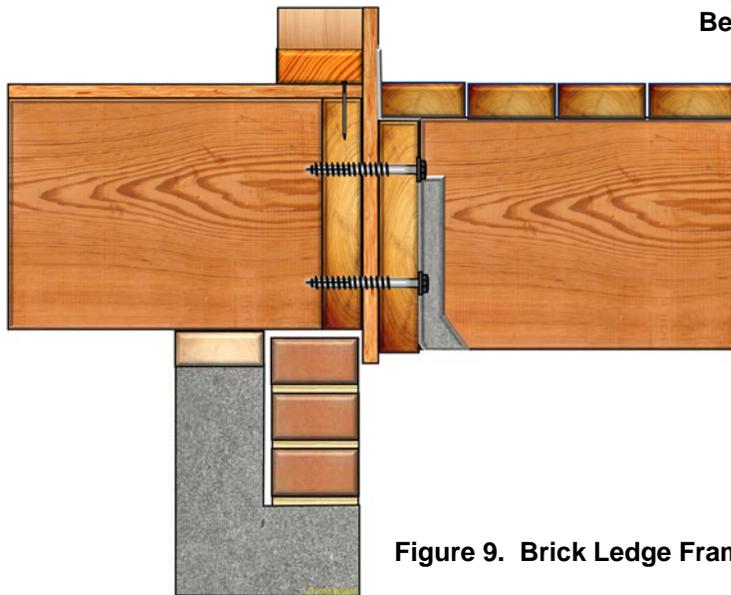
**Figure 6. Example of Deck Ledger Attachment to House Bump-Out Cantilever**



**Figure 7. Deck Ledger Attachment to House Bay Window Cantilever**



**Figure 8. Band Joist Separation From House When Band Joist Is Unsupported by a Sill Plate or Other Bearing Member**



**Figure 9. Brick Ledge Framing Cantilever**



**Figure 10. Bearing Deck Ledger Improperly Bolted To the Web of a Wood Composite I-joist**



**Figure 11. Bearing Deck Ledger Improperly Bolted to Exterior OSB Sheathing With No Additional Support**

commonly observed in the field (Figures 5 to 7), DCA 6 prohibits these connections, and section R507.2 of the IRC implies that such connections can only be made to band joists that rest directly on a sill plate or wall plate. Ledger attachments to a non-supported band joist are therefore subject to shear failure at the connection between the band joist and the ends of the house floor joists. A potential mode of failure for a cantilever connection is illustrated in Figure 8, where the ledger remains solidly bolted to the band joist, but the band joist separates from the house joist ends.

Cantilever connections are usually easy to identify but can be less obvious when the cantilever involves a short projection over an exterior brick or other veneer as illustrated in Figure 9. In such cases, from an exterior view of the structure, the deck-to-house connection may appear to be correct because there is no discernable cantilevered projection. Unless the interior floor framing structure is visible, the concealed cantilever arrangement makes it difficult to determine. The American Wood Council recently provided the following clarification on brick ledge cantilevers:

*Any cantilever of the house floor structure over a bearing wall in which the house band joist or rim joist does not have full bearing support would qualify as a cantilever per DCA 6. In*

*such cases, a non-ledger deck or engineering evaluation would be required. (AWC 2016).*

Examples of non-compliant ledger attachments abound in practice. Figure 10 shows a ledger improperly attached to an I-joist rim board. Figures 11 and 12 show a ledger attached only to exterior sheathing. Figure 13 is a photograph of a ledger connected to the ribbon boards of an open web floor truss system. Figure 14 depicts an improper ledger lag screw placement with respect to the interior band joist. Figure 15 shows an improper ledger connection through an exterior man-made stone veneer. Some older decks were attached to the house using only nails. It is still quite common to find these decks during a home inspection (Figure 16). Figure 17 is a photograph on another non-conforming connection; that of a perpendicular beam (carrying floor joists) to the ledger board. IRC section R507.2 specifically prohibits this connection, though it is still found in field inspections.



**Figure 12. Bearing Deck Ledger Improperly Attached to Plywood Sheathing**



**Figure 13. Bearing Deck Ledger Improperly Attached to Ribbon Board and Spacer Block in Open Web Floor Truss Assembly**



**Figure 14. Lag Screw Improperly Securing Deck Ledger Without Proper Edge Distance From House Band Joist. Note Corrosion At Lag Screw.**



**Figure 15. Bearing Deck Ledger Improperly Attached Through Adhered Masonry Veneer**



**Figure 16. Bearing Deck Ledger Improperly Attached to Brick Veneer Using Nails**

**Figure 17. Beam Placed Perpendicular to Band Joist Supporting Floor Loads Without Proper Bearing Support**



**Figure 18. Structural Deterioration of Wood Behind Band Joist. No Ledger Flashing Present.**

**Figure 19. Structural Deterioration of Band Joist Related to Improper Flashing**

None of these ledger attachments comply with the prescriptive guidance.

### Flashing

Properly installed deck flashing is essential for maintaining the integrity of the ledger connection to the band joist/rim board. Flashing should be installed over the entire length of where the deck ledger is attached to the house. Note that there are two types of flashing – back flashing and ledger flashing. Ledger flashing is a 'Z'-shaped flashing above the ledger that helps keep water from getting between the deck ledger board and the house band joist as shown in Figure 8. Back flashing is installed flat against the house band joist *before* the deck ledger is attached. Figure 18 is a photograph of structural decay behind a ledger board due to a lack of ledger flashing. Flashing should also be installed at doors that open on to the deck. Figure 19 is a

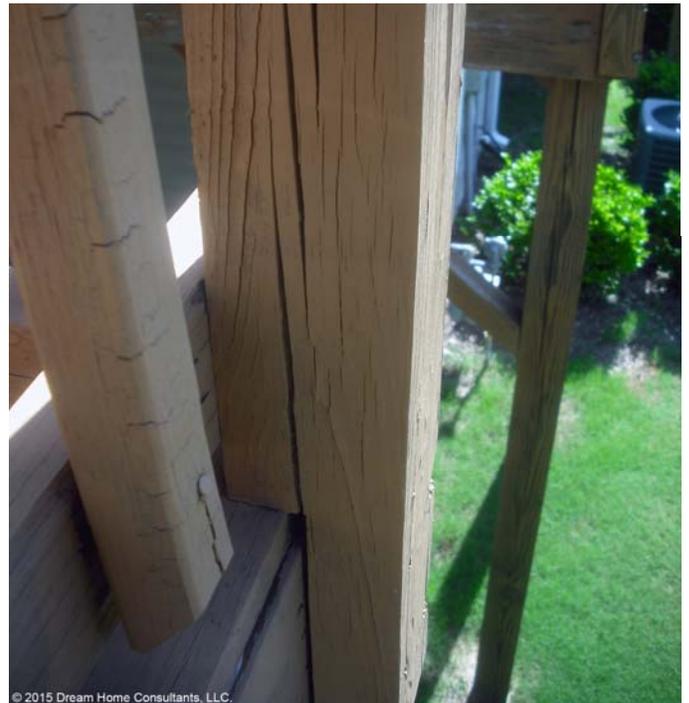


**Figure 20. Notched Guard Posts Only Attached With Nails Are Non-Compliant**

photograph of one such doorway where the flashing was inadequate to prevent moisture intrusion and consequent framing rot. All flashing should be integrated into the water-resistive barrier system to create a drainage plane.

Flashing materials must be compatible with the deck materials as discussed earlier in this paper. Galvanized steel flashing is allowed, but is not recommended, because of corrosion potential. Newer decks are being flashed using various types of plastic such as flexible polyethylene fabric, vinyl, and PVC. These new flashing products are superior to metal flashing in terms of corrosion; however, being new products, they have a limited track record regarding long term reliability.

### Guard Post Connections



**Figure 21. Notched Guard Posts Only Attached With Nails Are Non-Compliant. Note Splitting of Post At**

Testing conducted by Loferski et al. (2006) found that common connection guard post connection methods did not comply with the IRC mandated 200 pound design load requirement. Yet many of these inadequate connection methods are observed in the field. Guard installation defects that are frequently observed in the field include notched guard posts, (Figures 20 - 21), guard posts secured using only nails, (Figure 22), and guardrail systems with no guard posts at all (Figure 23). There are, of course, many other types of guard defects, including those involving poor baluster attachment and incorrect baluster spacing. Figure 24 shows a failure mode for a guard post attached to the outer band joist where the band joist fasteners are attached in withdrawal



**Figure 22. Notched Guard Posts In Two Directions and Only Secured With Nails Are Non-Compliant**



Figure 23. Missing Guard Posts in Railing

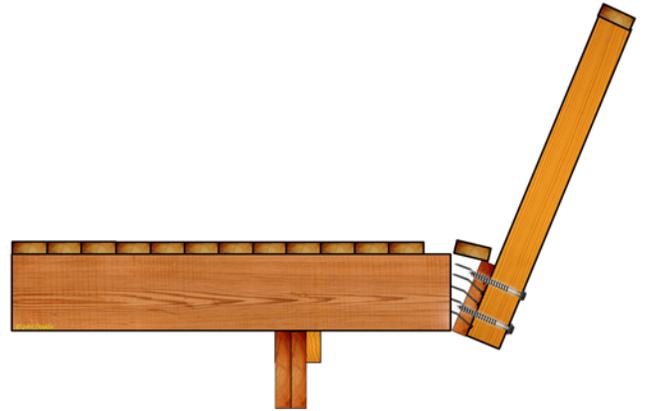


Figure 24. Failure Mode for Guard Posts Connected To Band Joist, Where Band Joist Peels Away from Deck Joists



Figure 25. Failure Mode for Notched Guard Post Where Post Splits Vertically



Figure 26. Dropped Header Held By Nail Cleats Supporting Stair Stringers. Cleat Nails are Loaded in



Figure 27. Shallow Throat Depth At Stringer Cuts



Figure 28. Recessed Ledger Screws Reduce the Effective Thickness of Ledger and Are Non-Compliant. Also, Note Improper Attachment to Brick



**Figure 29. Rusting Roofing Nails (Improper Fasteners) Connecting Hanger Hardware**



**Figure 30. Missing Fasteners in Designated Holes Within Hanger Hardware. Note Recessed Bolt in Ledger is Non-Compliant.**



**Figure 31. Bent Flanges of Hanger Hardware Are Non-Compliant.**

from the end grain of the deck joists, and Figure 25 depicts a potential failure mode for notched guard posts.

### ***Stairs and Railings***

Stairways are inherently dangerous even when built properly, and IRC requirements such as guardrail heights, stair step height and consistency requirements, and handrail configurations are the same for exterior stairs as for interior stairs. Deck stair defects are common, and include uneven riser heights and uneven tread depths, handrails that are not graspable, and lack of a solid landing at the bottom of stairs. Deck stair installation defects most likely to cause stair failure include stringers attached to drop headers attached by nails (Figure 26), and stringers with insufficient throat depth (Figure 27).

### ***Connector Hardware***

Connectors include joist hangers, post caps and post bases, and uplift connectors. The wide array of proprietary products and the complex rules governing their selection and installation makes it difficult for non-design professionals to determine if the correct connector has been used, and if it has been installed correctly.

As mentioned previously, hot-dipped galvanized steel connectors with a minimum galvanization level of G185 are required. For decks in severe environments such as those in coastal locations, stainless steel connectors and fasteners are recommended. Hot-dipped galvanized fasteners should be used with galvanized connectors and stainless steel fasteners with stainless steel connectors.

Some of the most common connector installation problems include the use of drywall or wood screws with hanger hardware (Figure 28), use of the wrong size or types of nails (in this case roofing nails) (Figure 29), using too few fasteners for the connections (Figure 30), and modifying the connectors (Figure 31).

### ***Conclusions***

There are certain observed construction related problems that occur in decks frequently. Knowing what these issues are is a good first step towards preventing them, or at least discovering them by inspection so that they can be corrected. Bearing ledger and guard post

connections are the two of the most common defects associated with deck failures involving injuries. Design professionals may find it helpful to anticipate the recurring construction problems shown in this paper and incorporate specific guidance in design drawings to help prevent them. Construction and inspection professionals may benefit from improved clarity and specificity in code language.

Since existing decks are generally not legally subject to updated code requirements, they can present a whole different set of inspection challenges. Development of a recommended inspection interval and a systematized inspection protocol based on predictable problem areas may prove useful in evaluating these decks for safety concerns.

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